

^{137}Cs and ^{90}Sr content in foodstuffs in the Czech Republic

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Abstract. The paper presents the results of long-term monitoring of ^{137}Cs and ^{90}Sr content in selected groups of foodstuffs. In 2010 the ^{137}Cs specific activities of the various kinds of meat, vegetable, fruit, grain and milk were usually in the range from less than 0.01 Bq/kg to 2 Bq/kg and in sylvan ecosystem foods from less than 0.04 Bq/kg to 1400 Bq/kg. The ^{90}Sr specific activities in liquid milk were usually from less than 0.02 Bq/L to 0.09 Bq/L and in mixed diet from less than 0.01 Bq/day to 0.09 Bq/day in 2010. On the base of market basket the daily intakes of ^{137}Cs and ^{90}Sr were estimated. The results for ^{137}Cs were compared with the intake estimated on the basis of determination of ^{137}Cs content in urine. The estimate of the ^{137}Cs intake in the 2010 based on the market basket including sylvan ecosystem foods was 310 Bq, without sylvan ecosystem foods 30 Bq and based on the measurement of ^{137}Cs activity in 24h urine 64 Bq. The estimated intake of ^{90}Sr based on the measurement of mixed diet was about 21 Bq in the 2010.

1. INTRODUCTION

Monitoring of radionuclide content in foodstuffs has been performed by Radiation Monitoring Network (RMN) in the Czech Republic (CR) since 1986. At present gamma-emitting radionuclides in foodstuffs and water samples are determined in seven laboratories using HPGe detectors with relative efficiency of 20-150 % and ^{90}Sr in 2 laboratories. The foodstuff samples originated from producers and traders as well. They were collected according to the monitoring programme specifying minimum numbers of samples collected from different parts of the CR. The numbers of samples varied during the monitoring period and the collections were not always homogeneous over the territory of the republic. The monitored foodstuffs include various kinds of meat, potatoes, vegetable, fruit, grain and grain products, milk and milk products and products of sylvan ecosystems (mushrooms, wild berries and game). ^{137}Cs has been determined in separate kinds of foodstuff, ^{90}Sr separately in milk, up to the year 2007 also in grain, and since 2007 in mixed diet.

For the statistical evaluation (on assumption of log-normal distribution of the data) a method was chosen which allows to include values lower than decision thresholds (MSA – minimum significant activity) according to maximum likelihood method [2]. Geometric mean (GM), geometric standard deviation (GSD) and arithmetic mean (AM) were calculated from parameters of log-normal distribution μ and σ according to the equations (1), (2) and (3)

$$GM = e^{\mu} \quad (1)$$

$$GSD = e^{\sigma} \quad (2)$$

$$AM = e^{\left(\mu + \frac{\sigma^2}{2}\right)}$$

2. RESULTS AND DISCUSSION

This paper presents the results of long-term monitoring (1986-2010) of ^{137}Cs and ^{90}Sr content in selected groups of foodstuffs.

The sharp decrease of ^{137}Cs specific activity in many kinds of foodstuffs in the first five years after the Chernobyl accident was followed by lower decrease in successive years; the mean annual values were mainly influenced by the statistical fluctuation of the data. The sylvan ecosystem products demonstrated weaker decline of specific activities. The time dependences of the calculated annual arithmetic means of ^{137}Cs activities in beef ($\text{Bq}\cdot\text{kg}^{-1}$), pork ($\text{Bq}\cdot\text{kg}^{-1}$) and milk ($\text{Bq}\cdot\text{L}^{-1}$) in the period of 1986-2010 are shown in Fig. 1 [1].

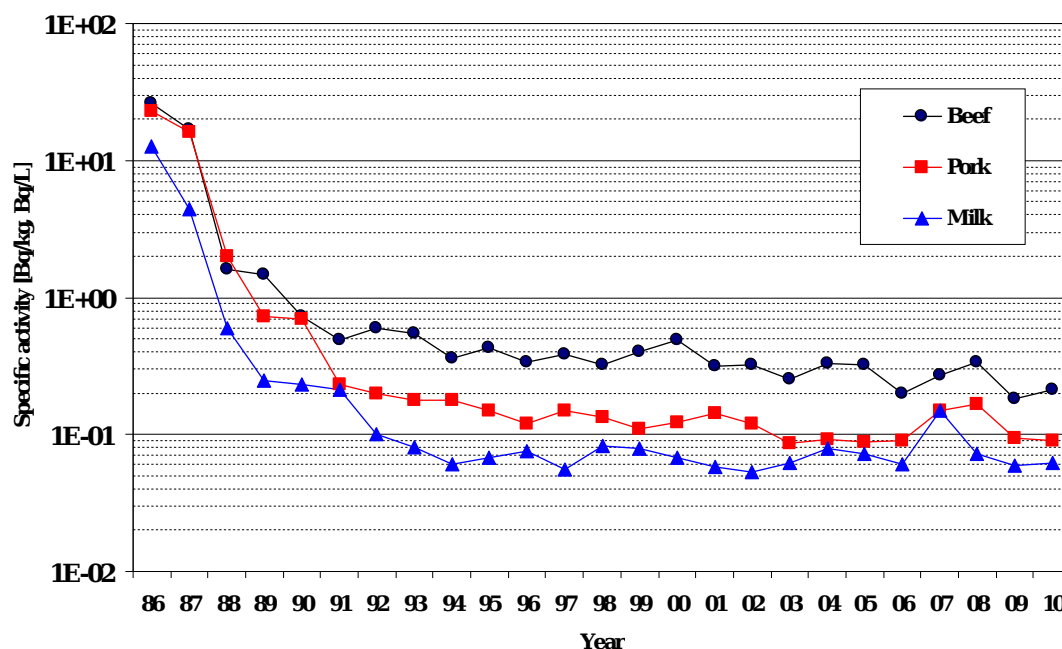


Figure 1. The estimate of annual arithmetic means of ^{137}Cs specific activities for beef ($\text{Bq}\cdot\text{kg}^{-1}$) and pork ($\text{Bq}\cdot\text{kg}^{-1}$) and activity concentration in milk ($\text{Bq}\cdot\text{L}^{-1}$) in the Czech Republic (1986– 2010).

The actual values of ^{137}Cs specific activity in many samples are very low. High efficiency HPGe detectors, concentration methods and long time counting are used to attain minimum significant activity (MSA) of ^{137}Cs lower than the actual specific activity. Despite use of concentration methods the determined ^{137}Cs specific activities have often been lower than MSA in the last years; the specific activities of ^{90}Sr in monitored samples have usually been higher than MSA.

In 2010 the ^{137}Cs specific activities of the various kinds of meat, vegetable, fruit, grain and milk were usually in the range from less than 0.01 Bq/kg to 2

Bq/kg, in game in the range from less than 0.05 to 1400 Bq/kg, in wild berries in the range from less than 0.04 to 38 Bq/kg and in mushrooms in the range from 0.05 to 460 Bq/kg. The ^{90}Sr specific activities in liquid milk were usually in the range from less than 0.02 Bq/L to 0.09 Bq/L and in mixed diet in the range from less than 0.01 Bq/day to 0.09 Bq/day in 2010.

For distributions of ^{137}Cs activities in vegetable, fruit and products of sylvan ecosystem high GSDs and thus high differences between the values of arithmetic and geometric means were found. High GSDs are caused by non-homogeneity of ^{137}Cs fallout on the CR territory after the Chernobyl accident (mainly in the case of products of sylvan ecosystem) that brought about a wide range of the data; high GSDs are also caused by large amount of values under MSA (mainly in the case of vegetable and fruit) and also by non-homogeneity of the collection of samples over the territory of the CR in each year.

For kinds of foodstuffs with more than 50 % of values under MSA and in case of lacking data in some years, statistical evaluation and mean estimations over several years were done.

Total ^{137}Cs intake from the foodstuffs was estimated as the sum of products of the arithmetic mean of activity concentration and consumption of given kind of foodstuff for all monitored years. The contributions (in %) of ^{137}Cs intake from consumption of individual kinds of foodstuffs to the whole intake of ^{137}Cs in the year 2010 are presented in the table 1.

Table 1. The contribution (in %) of ^{137}Cs intake from consumption of individual kinds of foodstuffs to the whole intake of ^{137}Cs in the year 2010

Food commodity	With products of sylvan ecosystem	Except products of sylvan ecosystem
	%	%
Potatoes	1.2	12.7
Poultry	0.5	5.0
Beef	0.7	7.2
Pork	1.3	13.4
Milk and milk products	2.4	25.5
Grain and grain products	2.5	26.5
Fruit	0.3	3.2
Vegetable	0.6	6.6
Wild mushrooms	77.5	
Wild berries	6.1	
Game	7.0	
	100.0	100.0

The estimate of the ^{137}Cs intake in the 2010 based on the market basket with the inclusion of sylvan ecosystem was 310 Bq, based on the market basket without sylvan ecosystem foods 30 Bq and based on the measurement of ^{137}Cs activity in 24h urine 64 Bq. The estimate of the intake of ^{90}Sr based of the measurement of mixed diet was about 21 Bq for the 2010.

Wild berries, game and mainly wild growing mushrooms can contain order of magnitude higher activity concentrations then other foods, so these products of sylvan ecosystem can have the highest effect on the intake of ^{137}Cs . Their consumption based on the survey in CR is 2.4 kg, 1.3 kg and 0.28 kg for

mushrooms, wild berries and game, respectively. Unfortunately, the activity concentrations vary in wide range over the territory of Czech Republic the same as their consumption in the population. This can be the reason why the estimate of the intake based on the measurement of urine is lower than the estimates based on the market basket including sylvan ecosystem foods. The time of collection of urines, every year in May, can also help to explain the differences, because the main season of mushrooms picking comes later than the collection of urines.

3. CONCLUSIONS

^{137}Cs content in different kinds of foodstuffs decreased sharply in approximately first five years after 1986. In the consecutive years the decrease was not so pronounced. Wild berries, games and mainly wild growing mushrooms can contain order of magnitude higher activity concentrations than other foods, so these products of sylvan ecosystem can have the highest influence on the intake of ^{137}Cs . During the last years the determined ^{137}Cs contents in other foods were often lower than detection limit of the used analytical procedure.

In 2010 the ^{137}Cs specific activities of the various kinds of meat, vegetable, fruit, grain and milk were usually in the range from less than 0.01 Bq/kg to 2 Bq/kg, in game in the range from less than 0.05 to 1400 Bq/kg, in wild berries in the range from less than 0.04 to 38 Bq/kg and in mushrooms in the range from 0.05 to 460 Bq/kg. The ^{90}Sr specific activities in liquid milk were usually in the range from less than 0.02 Bq/L to 0.09 Bq/L and in mixed diet in the range from less than 0.01 Bq/day to 0.09 Bq/day in 2010.

The estimate of the ^{137}Cs intake in the 2010 based on the market basket including sylvan ecosystem foods was 310 Bq, based on the market basket except sylvan ecosystem foods 30 Bq and based on the measurement of ^{137}Cs activity in 24h urine 64 Bq. The estimate of the intake of ^{90}Sr based on the measurement of mixed diet was about 21 Bq for the 2010.

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